Mesoscale Dynamics of the Adriatic Sea

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LONG-TERM GOALS

A better understanding of oceanic variability via modeling studies of circulation, entrainment, mixing and convection in the coastal ocean. Development and use of high-resolution models for the study of dynamic processes and for the investigation of specific oceanic regions. Transition of these models to the US Navy.

OBJECTIVES

The particular objective of this project is to understand the physics of the mesoscale motions across the Adriatic Sea well enough to simulate them faithfully in high-resolution models.

APPROACH

The approach is two-fold, combining (1) the development of a very-high-resolution 3D model for the entire Adriatic basin with (2) the analysis of existing satellite imagery and in-situ data revealing mesoscale spatial patterns. The selected model is DieCAST because of its extremely low level of dissipation at the grid scale, and the satellite images of choice are AVHRR and SeaWiFS, especially the latter because of the high level of details they provide; most useful in-situ data are drifter tracks. The project is integrated in the ONR-sponsored Dynamics Of Localized Currents and Eddy Variability In The Adriatic (DOLCE VITA) Program.

WORK COMPLETED

The DieCAST ocean model has been applied in a high-resolution mode to the entire Adriatic Sea [1]. Specific tasks performed during this last year were a series of simulations of the Adriatic response to several bora events [2] and detailed consideration of mesoscale variability along the Italian coast from Rimini (44oN) to Gargano (42oN) [paper in preparation]. The work included the search for, and compilation of, COAMPS wind data sets and simultaneous satellite images that include representative wind events of the Adriatic Sea. The set includes the specific bora event of February 2003, which took place during the intensive DOLCE VITA data campaign. Although the first simulation trials reported last year were very encouraging, it was decided to explore this year the reason behind the discrepancies, and several scenarios were pursued in which modifications were made to the model, variant initial conditions were applied, and several different variations of the forcings were applied.

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As opportunities arise and spontaneous ideas emerge, some work connected with coastal processes was pursued alongside the main objectives of this project. These collateral investigations included studies of shear turbulence, Kelvin-Helmholtz instability and barotropic instability as boundary-value problems [3, 4 & 5].

RESULTS

The various model simulations of the same 2003 bora wind event demonstrated that DieCAST is an excellent tool to simulate mesoscale processes and instabilities at the scale at which they occur in the Adriatic Sea. However, accurate representation of the features as they occur can only be obtained if the simulations are initialized and forced by similarly accurate data (Figure 1). In other words, the limiting factor in the simulations with DieCAST is not the model *per se* but the input that is provided to it.

IMPACT/APPLICATIONS

The results to date demonstrate that effective simulations of the mesoscale variability of the Adriatic Sea require a low-dissipation model, a grid resolution of at least 2 km, AND surface forcings (wind stress and heat flux) of similar spatial resolution. This ought to impact the Mediterranean Sea models currently used by the US Navy. It also leads us to anticipate success when DieCAST is later configured with data assimilation.

RELATED PROJECTS

This project is a component of the multi-project DOLCE VITA Program funded by ONR-PO and focusing on the Adriatic Sea. Related projects are those of Craig Lee (Univ. Washington, TriSoarus towed profiling), Pierre Flament (Univ. Hawaii, HF radar and remote sensing), Pierre-Marie Poulain and Elena Mauri (OGS-Trieste, surface drifters), and Mirko Orlic (Univ. Zagreb, East Adriatic Coastal Experiment).

PUBLICATIONS

1. Cushman-Roisin, B., K. A. Korotenko, C. E. Galos and D. E. Dietrich, 2006: Simulation and characterization of the Adriatic Sea mesoscale variability, *J. Geophys. Res. – Special Adriatic Issue*, favorably reviewed.

2. Cushman-Roisin, B., and K. A. Korotenko, 2006: Mesoscale-resolving simulations of summer and winter bora events in the Adriatic Sea, *J. Geophys. Res. – Special Adriatic Issue*, favorably reviewed.

3. Cushman-Roisin, B., 2005: Kelvin-Helmholtz instability as a boundary-value problem, *Environmental Fluid Mech.*, **5**, 507-525.

4. Cushman-Roisin, B., and A. D. Jenkins, 2006: On a non-local parameterisation for shear turbulence and the uniqueness of its solutions, *Boundary-Layer Meteorol.*, **118**, 69-82.

5. Cushman-Roisin, B., and A. J. Willmott, 2006: Barotropic instability of coastal flows as a boundary-value problem; linear and nonlinear theory. *Geophys. Astrophys. Fluid Dyn.*, favorably reviewed.
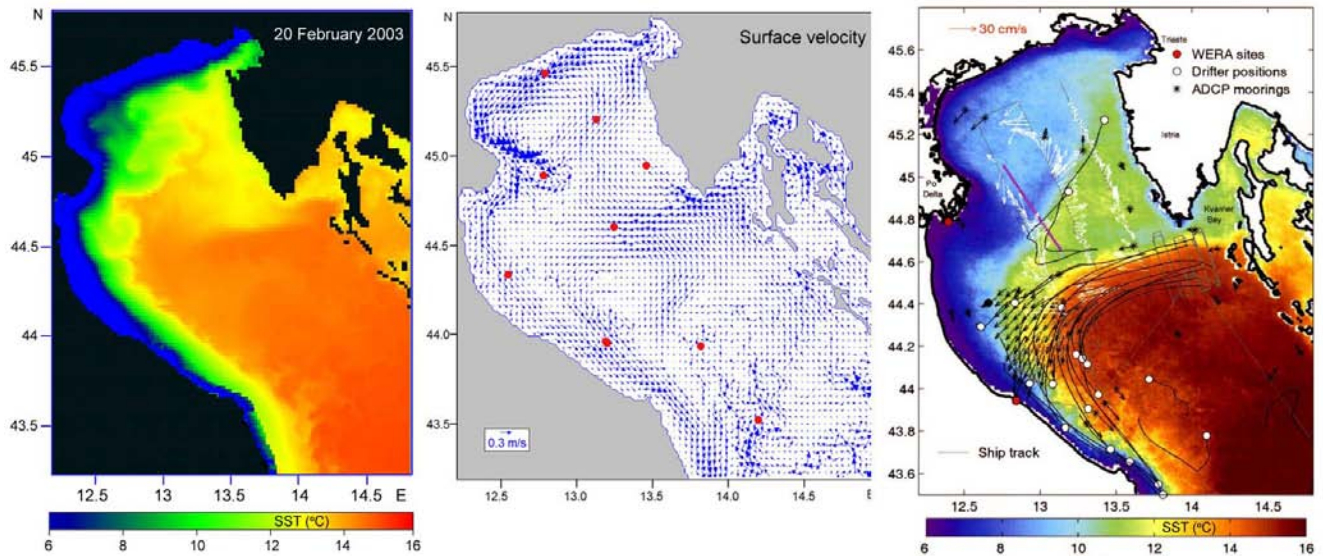
Figure 1. DieCAST-data comparison

Comparison of DieCAST model simulations of the bora event of late February 2003 with in-situ and satellite data collected during the DOLCE VITA Experiment. Left panel: simulated sea-surface temperature for 20 February; center panel: simulated velocity vectors for 20 February; right panel: superposition of satellite sea-surface temperature, drifters tracks and ship current measurements, collected over the period 11-20 February. (Note: The difference in colors between left and right panels is due to a difference in color palette; the temperature values are very similar between both images.) Every red dot in the middle panel indicates a location where simulated and observed currents were compared. Simulated velocities agree with measured values and those inferred from drifter data.